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The National Map Catalog Technical Discussion Paper
Viewscales and Their Effect on Data Display

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1 Introduction

One important characteristic of *The National Map* viewer is the availability of multi-scale data. The virtual map covers the entire country, and for any particular area may include hundreds of GIS data layers. Deciding which layers to display at what zoom factors is both important and difficult.

These decisions are related to map scale, data resolution, and the purposes of the application. Unfortunately, they do not correlate exactly to any of these factors. To see why this is true, consider a simple example of data being served from a county WMS. When the entire county is displayed in a typical browser window, the map may have a scale near 1:300,000¹. County application designers may decide that the boundary and major roads should be displayed at all times. This is reasonable behavior for the county application, but less reasonable when the same data are used in a national application. Displaying county boundaries at all times leads to a dense, cluttered map when the entire U.S. is displayed. But restricting the boundary display to 1:300,000 and larger scales would mean that no county boundaries are visible until a single county nearly fills the browser window. A national application probably wants county boundaries to be available for display at scales of around 1:3,000,000, when a State or group of States fills the browser window.

2 The Meaning of Viewscale

Display thresholds are stored in the *The National Map* Catalog in **decimal degrees per screen pixel**. The deg/pix value gets smaller as the scale of the display gets larger. These are typical values at selected zoom factors in *The National Map* viewer:

<u>Area displayed</u>	<u>deg/pix</u>
Continental US	0.100
Missouri	0.010
One Missouri county	0.001

Two viewscale values are assigned to every WMS layer. For a selected layer, the **maxviewscale** is the largest deg/pix value (smallest map scale) at which the layer is available for display. The maxviewscale for low-resolution or small-scale layers is relatively large. For a map service whose domain is North America, any value of maxviewscale greater than roughly 0.2 essentially means "display this layer no matter how far the display is zoomed out."

Similarly, the **minviewscale** is the smallest deg/pix value (largest map scale) at which a layer is made available to an application. For most layers this value is currently set to 0, which means "once visible, continue to make this layer available no matter how far the display is zoomed in." (As will be seen below, 0 is perhaps not the best choice for achieving this behavior.)

When many layers and large areas are involved, it is not easy to predict the visual effects that will result from various combinations of maxviewscale and minviewscale values. Experience to date has been that ongoing attention to and adjustment of viewscales is necessary.

¹ The numbers used in this example are order-of-magnitude. The apparent scale of a screen display is obviously affected by many factors, including the resolution of the monitor and the size of the browser window.

3 Current Viewscale Values

Fig 1 illustrates the max and min viewscales for selected layers in *The National Map*. The layers in the figure are mostly small-scale base layers, but also include several important larger scale layers. Pages at the end of this report contain similar charts for all layers, by data theme.

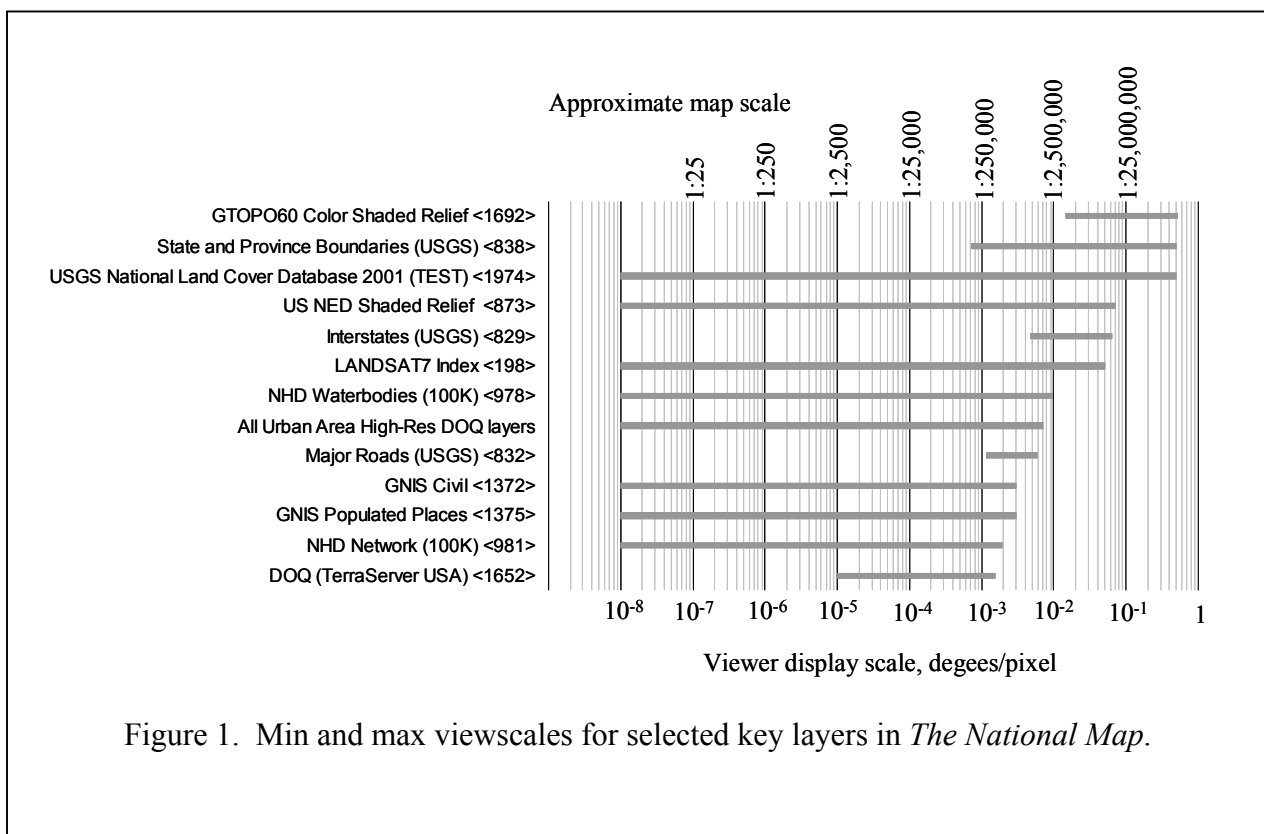


Figure 1. Min and max viewscales for selected key layers in *The National Map*.

The left side of each bar is the value of minviewscale, the right side maxviewscale. The length of the bar represents the range of scales at which the layer is available for viewing in the public viewer². The labels on the left side are layer names as they are stored in the Catalog; these names are the labels that display in public viewer to describe the layers³.

The x-axis of Fig 1 is a logarithmic scale. This is necessary because of the extremely wide range of data scales that are typically part of WMS applications. A viewscale value of (for example) .000287 equals 2.87×10^{-4} , which would fall between the 10^{-4} and 10^{-3} marks on the lower X axis, near the second line to the right of 10^{-4} .

The bottom of the x-axis is labeled with degree/pixel values stored in the Catalog and used by *The National Map* viewer application. The top of the x-axis is labeled with the approximate map scales

² The viewscale values stored in the Catalog do not, by themselves, dictate any application behavior. An application must read and interpret the viewscale values correctly. *The National Map* public viewer does this, but other applications could choose to ignore the viewscale values.

³ The numbers in angle brackets are not part of the layer name. They are the database ID numbers of the layers, added to the name string for the graphs in this report.

that correspond to the deg/pix values on the bottom. The map scales are only approximate because the scale of a map display on a computer screen depends on the size and resolution of the monitor. East-west scale also varies with latitude⁴. The values in the figure are for north-south scale on a 21" monitor with 1154x768 resolution.

The Catalog currently uses minviewscale values of 0 to indicate no "zoom in" limit. This works in computer applications, even though the math isn't quite right. A value of 0 deg/pix implies an infinite map scale; in the data used to construct the figures in this report, 0 was changed to 10^{-8} to allow the data to be plotted. More importantly, it is hard to imagine a GIS dataset for which viewscales much smaller than 10^{-8} deg/pix would make any sense.

Similarly, some maxviewscales in the Catalog are currently set to the exceptionally large value of 10 to indicate no "zoom out" limit. These values were changed to 0.5 for the plotted data in this report.

Therefore, on the plots in this report the full range of viewscales is 10^{-8} to $5 \cdot 10^{-1}$ degrees/pixel.

4 Discussion

4.1 Viewscales Tailored to Each Layer

Fig 1 illustrates several display scale characteristics that might be undesirable:

1. Three raster data sets (land cover, NED shaded relief, and urban area DOQs) have minviewscales of 0, which allows the user to zoom to pixel and even sub-pixel levels. At high zoom factors, raster datasets clutter the screen without showing any useful information.
2. Urban area high-res DOQs become available for display at scales nearly six times smaller than the scale at which standard DOQs become available for display.
3. NHD 100k water bodies become available for display at scales nine times smaller than 100k streams.

There is nothing exactly wrong with any of this, and it is even possible these characteristics of the data are intentional. But they are more likely a result of *The National Map* technical implementation getting ahead of data evaluation procedures.

4.2 Viewscales Set by the Data Provider

Viewscales can be set by the Web Map Service that provides the layer to *The National Map*. From the perspective of the service, the Catalog is just another application using the data, and cannot override restrictions placed on data display by the service. The application can make the viewscale values more restrictive than those defined by the service, but cannot make them less restrictive. For example, if a service allows data to be displayed at scales between 10^{-6} and 10^{-4} , the Catalog can make this range narrower, but cannot broaden it on either end.

In some cases, such as the county example in the introduction, service restrictions may preclude a reasonable display in a national application. In such a case, some compromise must be sought through negotiation with the partner.

⁴ Defining scale in degrees/pixel makes east-west scale vary with latitude. Only at the equator is the scale the same in all directions. This has the visual side effect in *The National Map* viewer of "stretching" the displays in the east-west direction, which makes circles display as ovals and squares display as rectangles or other non-square quadrilaterals.

4.3 Default Catalog Values

The Steering Team might want to assign one or more of the design teams the responsibility to establish some guidelines for viewscale values. There are at least two issues that deserve some attention:

- Is it desirable to set default limits on viewscale range, perhaps based on the nominal map scale of the data layer? It is currently common for the declared viewscale range to span five or more orders of magnitude.
- Is it wise to allow infinitely small and infinitely large viewscales for any dataset (the current range of 0-10). A maximum range of 10^{-8} to 10^{-2} might be more sensible.

4.4 Difficulties in Assessing Viewscale-Dependent Behaviors

Display scales in *The National Map* environment are obviously more complex than traditional map scales. The huge volumes of data and multiple scales make it difficult to make decisions about display scales from traditional cartographic experience.

Even understanding the meaning of actual current viewscale values is not especially easy. Producing the graphs in this report required software tools and specialized knowledge that, while technically available to anyone in the Geography Discipline, are not yet used by many people. Viewscales for all public layers were extracted from the Catalog database with an SQL query, and the data imported into an Excel spreadsheet to create the graphs.

The internal viewer MapView is also very helpful in analyzing the visual effects of viewscales. MapView exposes much detail that is hidden by the public viewer, including more precision on viewscale values and extensive service-level metadata about layers.

4.5 Points of Responsibility

At this writing, responsibility for making decisions about data parameters like viewscale has not been clearly assigned. In current practice, several groups have overlapping interests:

1. MPOs are responsible for working to define data presentations that are mutually acceptable the USGS and the partner. MPOs have been given broad authority to make decisions about data content and data presentation.
2. Base data design teams are responsible for defining data content standards for *The National Map*.
3. Catalog Support Teams are responsible for implementing partnerships by populating and maintaining the Catalog. In principle, the CST has no authority to make decisions about data content. But in actual practice, many of the details of data presentation – frequently including viewscale values – are left to the CST by default.

5 Making Changes

Viewscales values, while important to the look and feel of *The National Map* viewer, have not received a great deal of attention during the early stages of *The National Map* implementation.

The easiest way to request a change to a viewscale value is to send email to the CST at “GS-N-MCMC Catalog Support Team.” Include the name and ID number of the layer, and the

new deg/pix values of the desired max and min viewscales. Until different guidelines are established, such requests will be accepted from MPOs and design teams.

6 Viewscales for All Layers by Theme

The following pages contain graphs similar to Fig 1, but for all public layers in *The National Map*, organized by data theme. The graphs illustrate that the types of apparent anomalies described for the layers in Fig 1 are common in all data themes. Particularly noticeable is the large number of layers that have no “zoom in” limit – that is, the minviewscale is set to zero, so the layer will continue to display no matter how far the user zooms in.

The following SQL code, when run against the Catalog database at Oracle instance "test9i", will print a listing of layers with viewscales, by data theme. A similar query was used to generate the data for the graphs in this report.

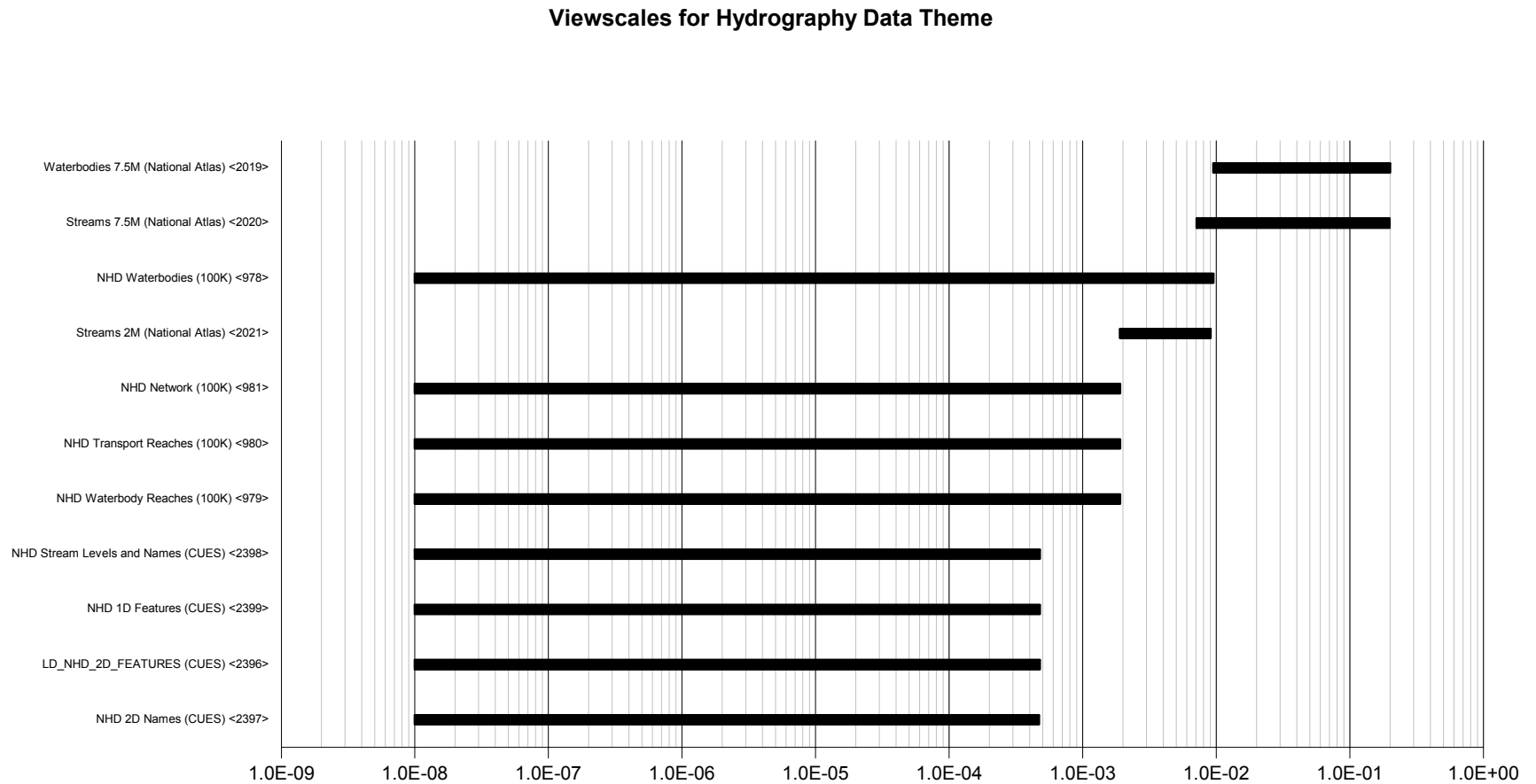
```
set linesize 140
set pagesize 52

column theme noprint format a30 new_value theme_name
column themeid noprint
column service format a30 heading 'Web Map Service' trunc
column subtheme format a12 heading 'Sub-Theme' trunc
column layer format a55 heading 'WMS Layer' trunc
column min format 90.9EEEE
column max format 90.9EEEE
set trimspool on

break on theme skip page on service

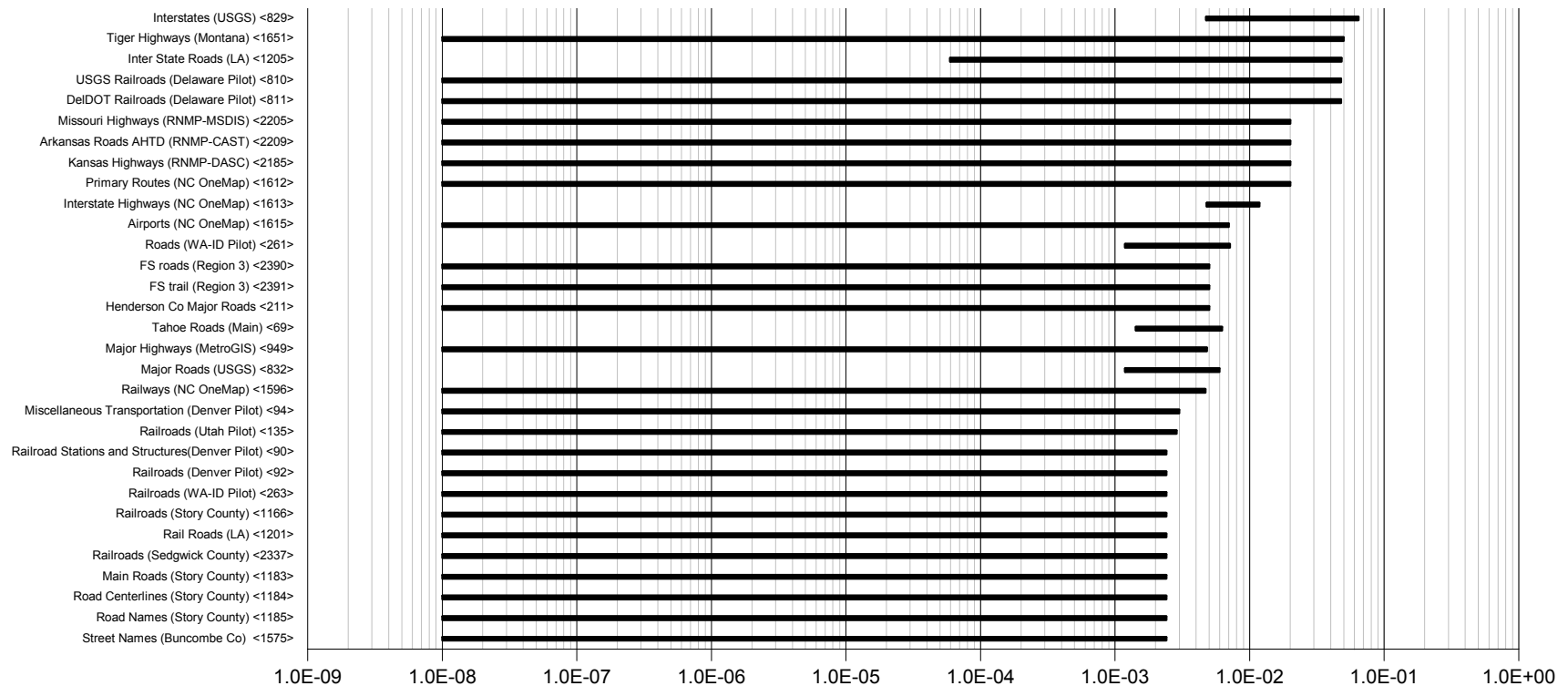
ttitle left 'Public Layers for ' theme_name skip 1

select themes.name theme,
       themes.id themeid,
       services.name service,
       classifications.name subtheme,
       to_number(elements.minviewscale) min,
       to_number(elements.maxviewscale) max,
       elements.title layer
from   themes,
       classifications,
       element_classifications ec,
       elements,
       services
where  themes.id=classifications.themeid
       and classifications.id=ec.classificationid
       and ec.elementid=elements.id
       and elements.serviceid=services.id
       and elements.status='PUBLIC'
       and services.status='PUBLIC'
order by themeid, service, subtheme, layer
/
```



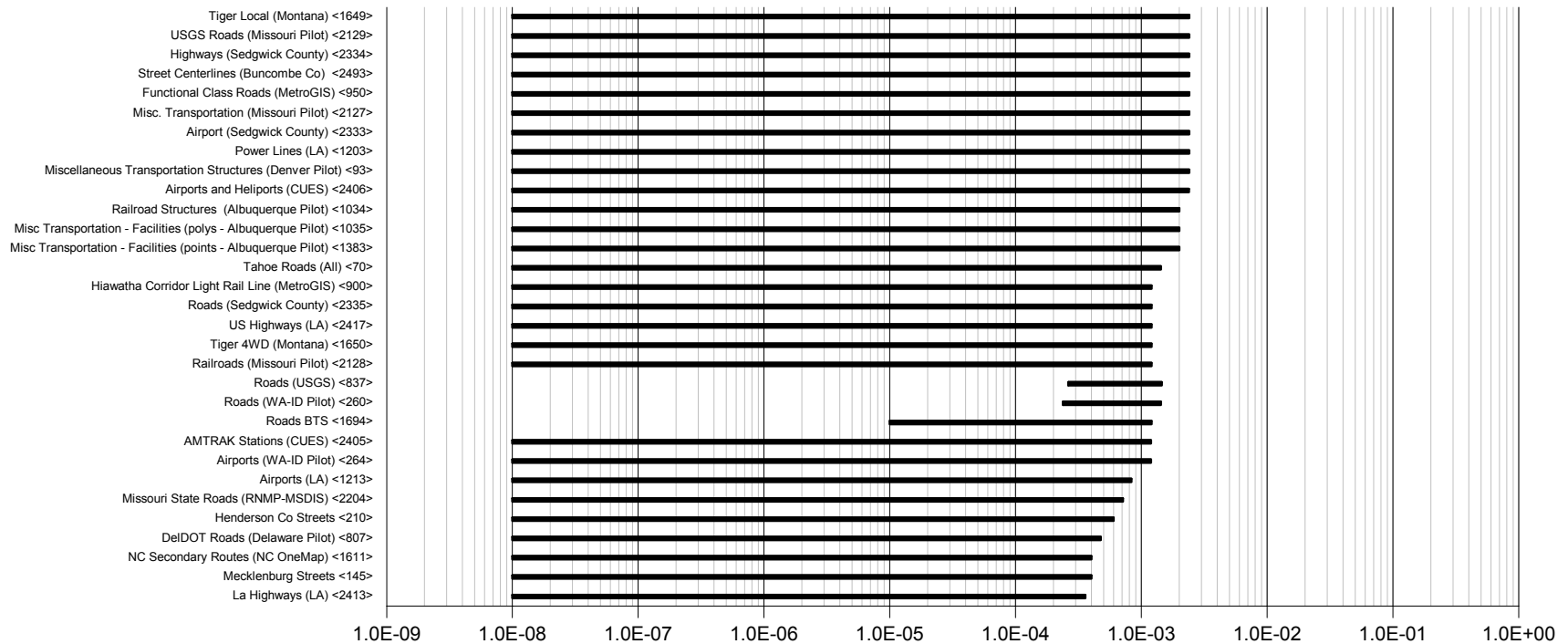
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Trans Data Theme (1)



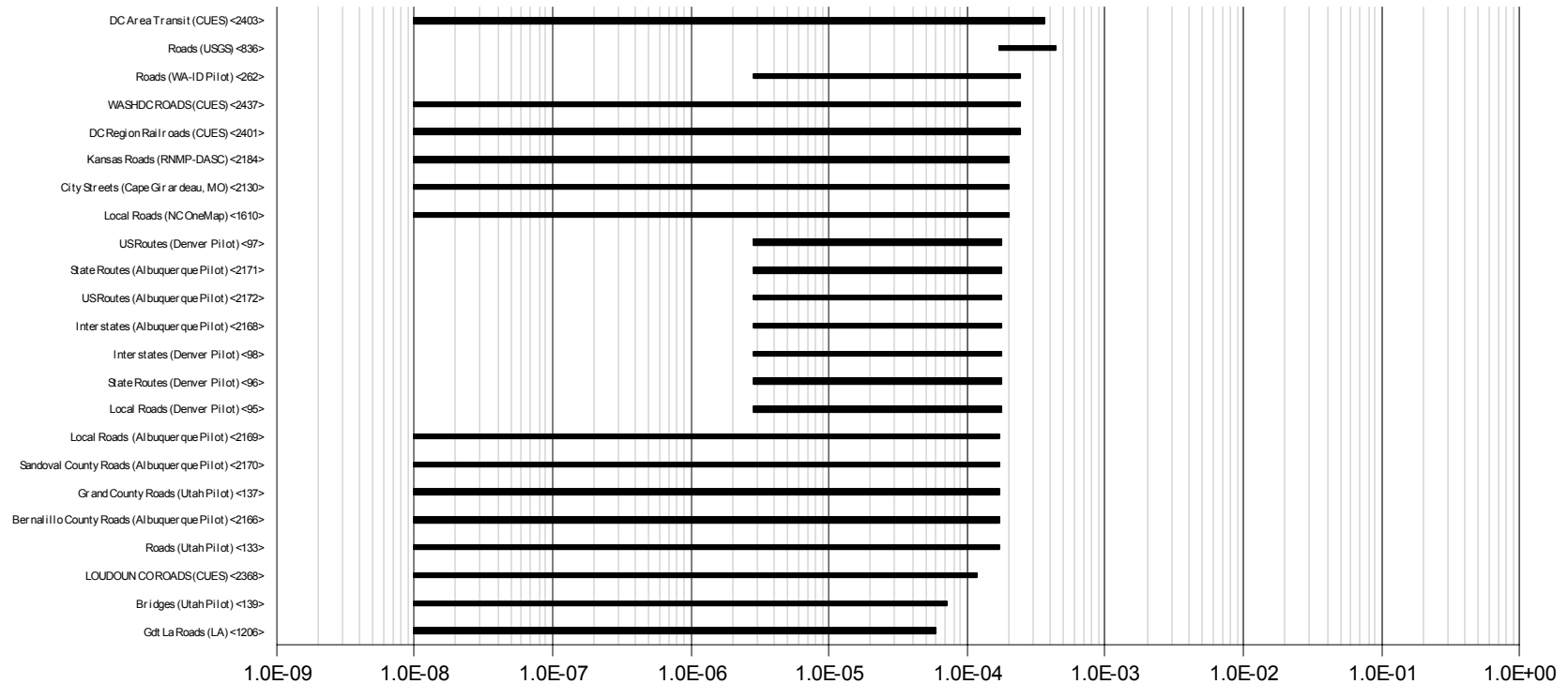
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Transportation Data Theme (2)



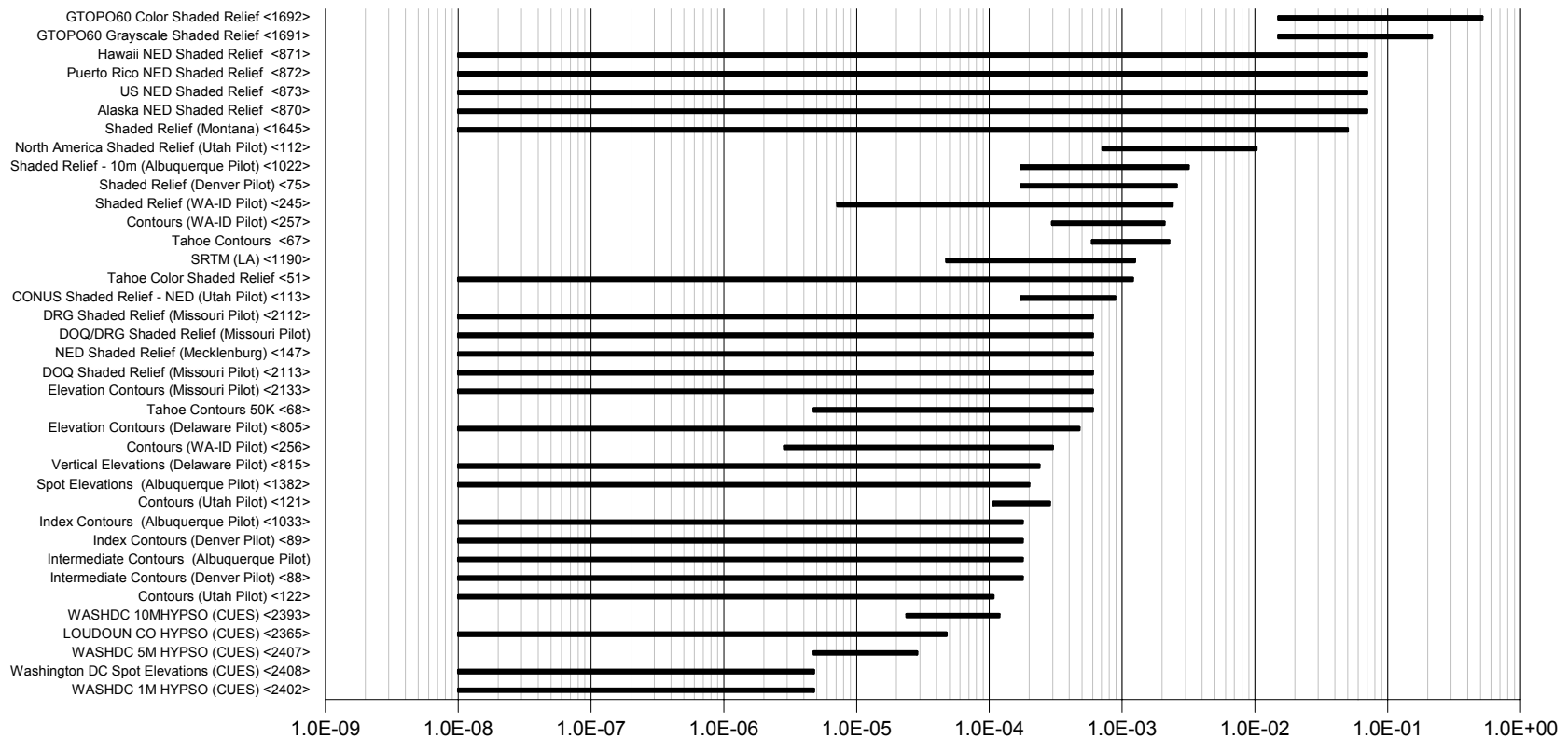
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Transportation Data Theme (3)



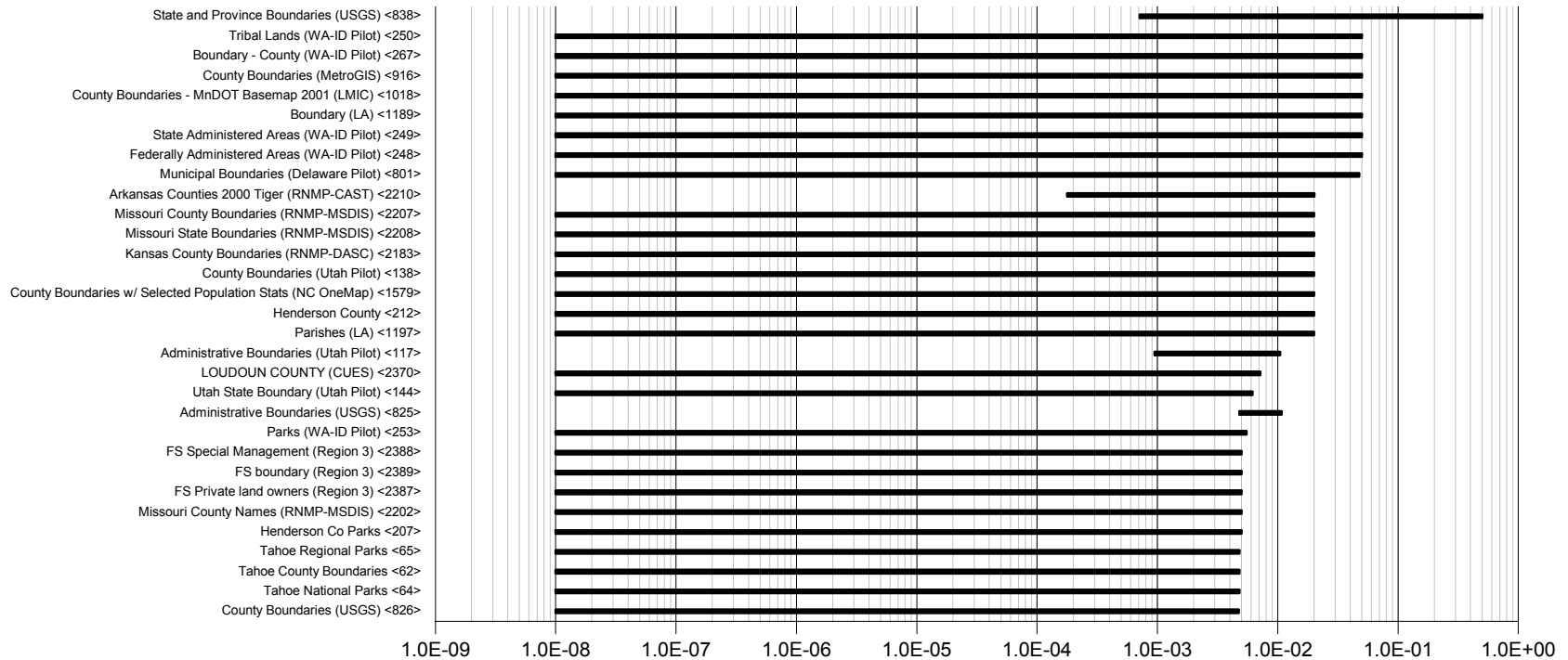
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Elevation Data Theme



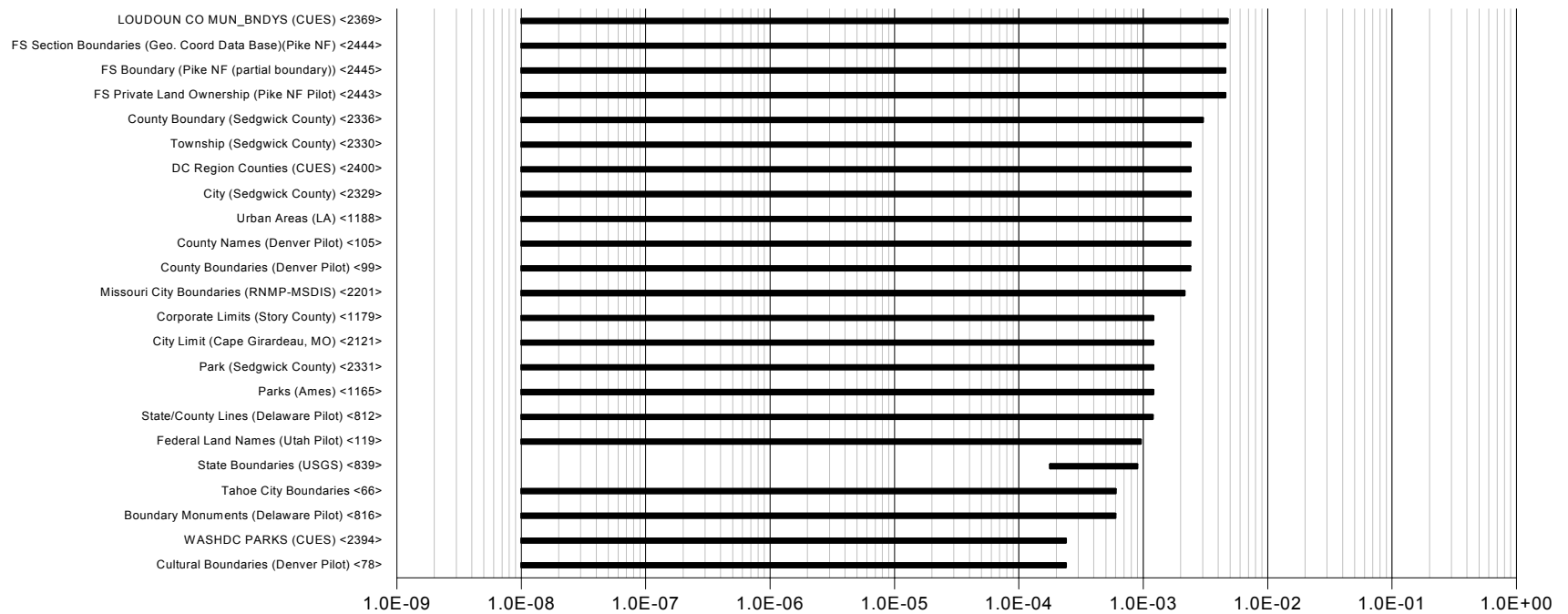
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Boundaries Data Theme (1)



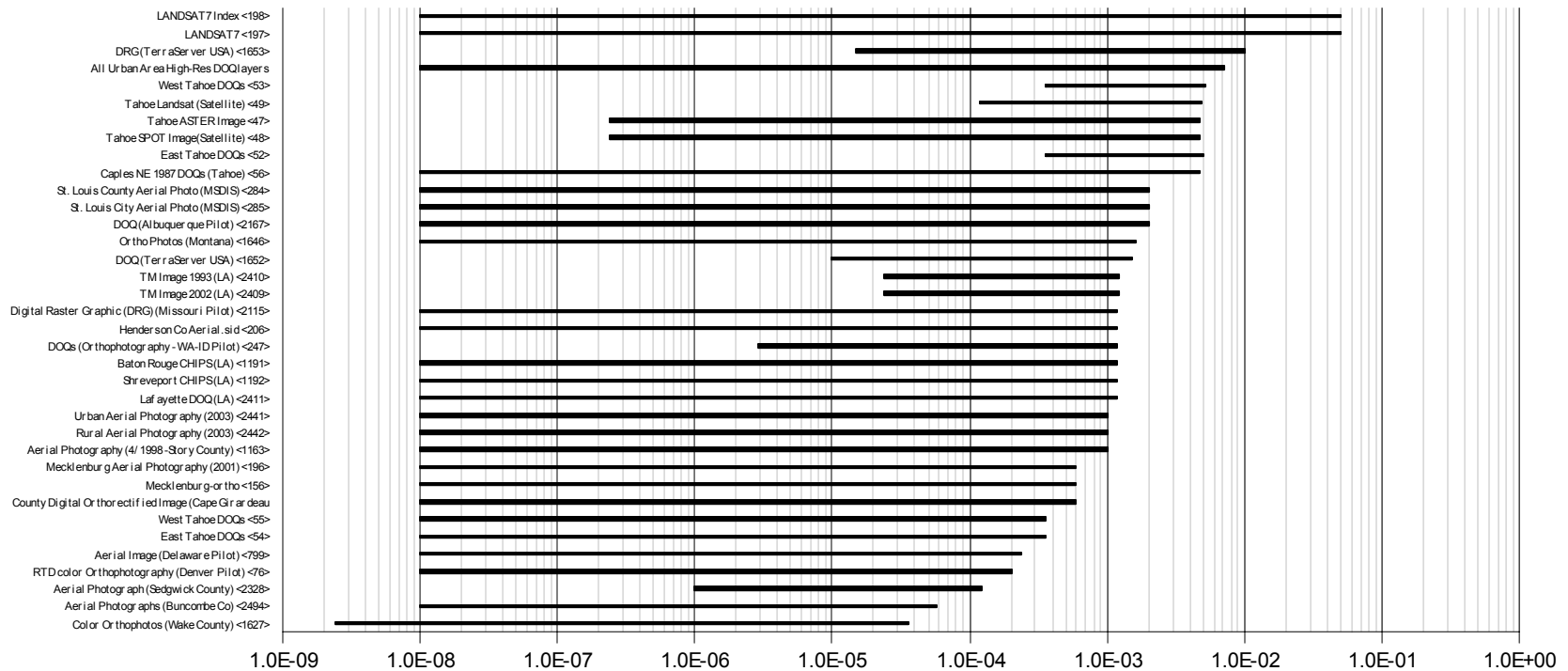
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Boundaries Data Theme (2)



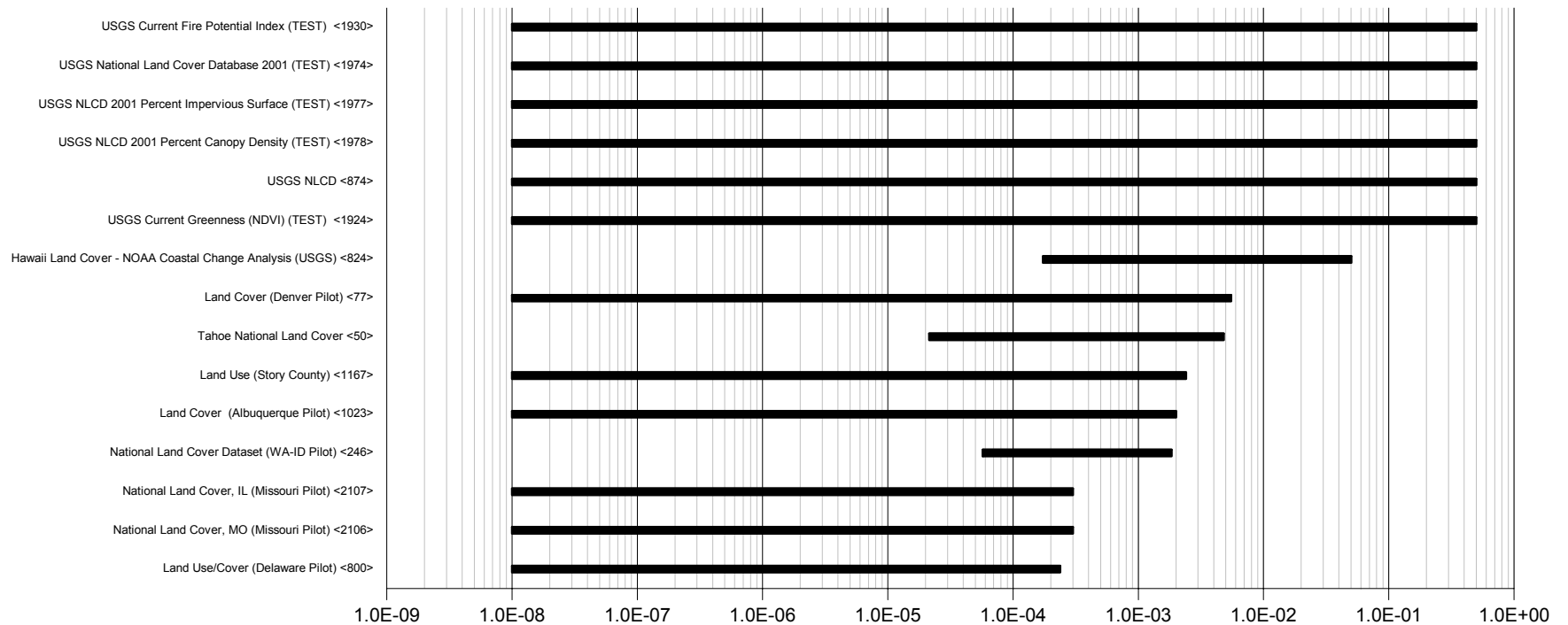
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Imagery Data Theme



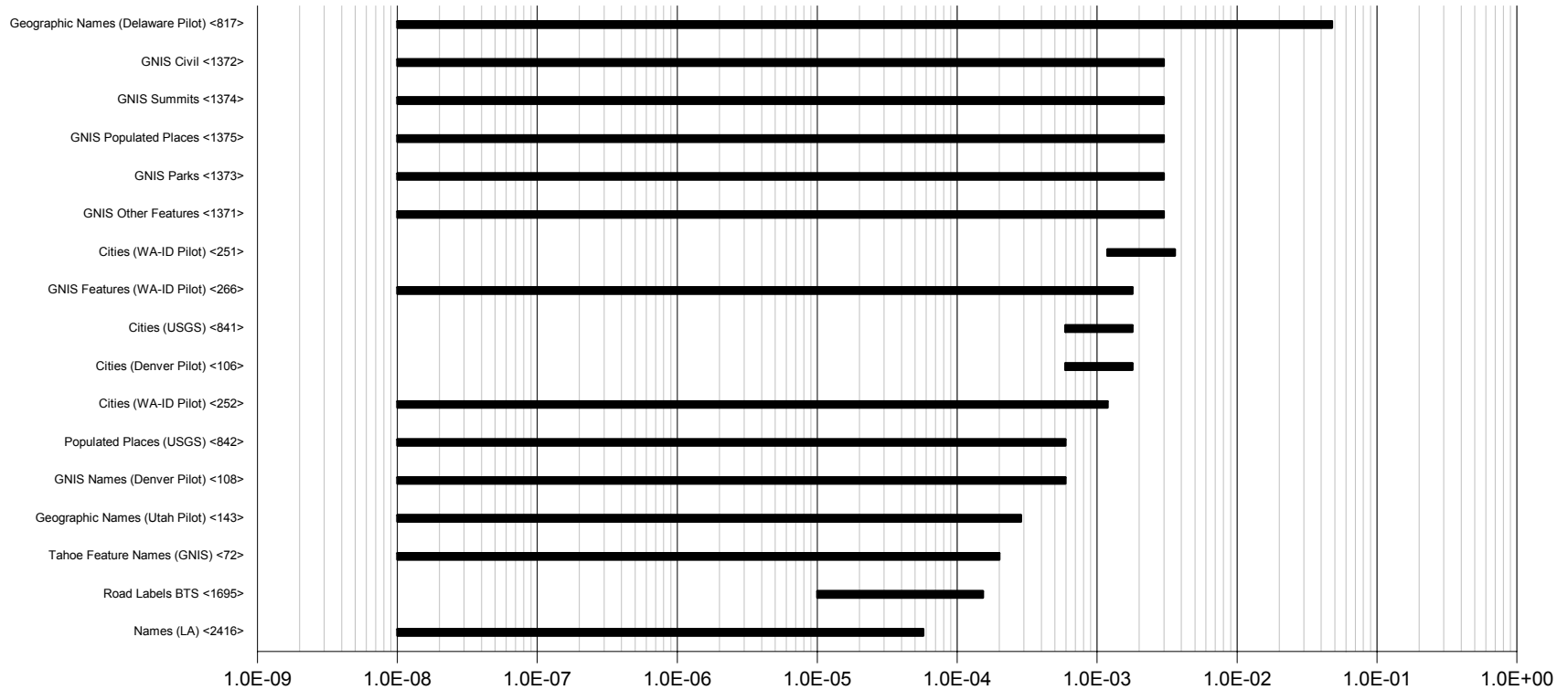
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Land Use Land Cover Data Theme



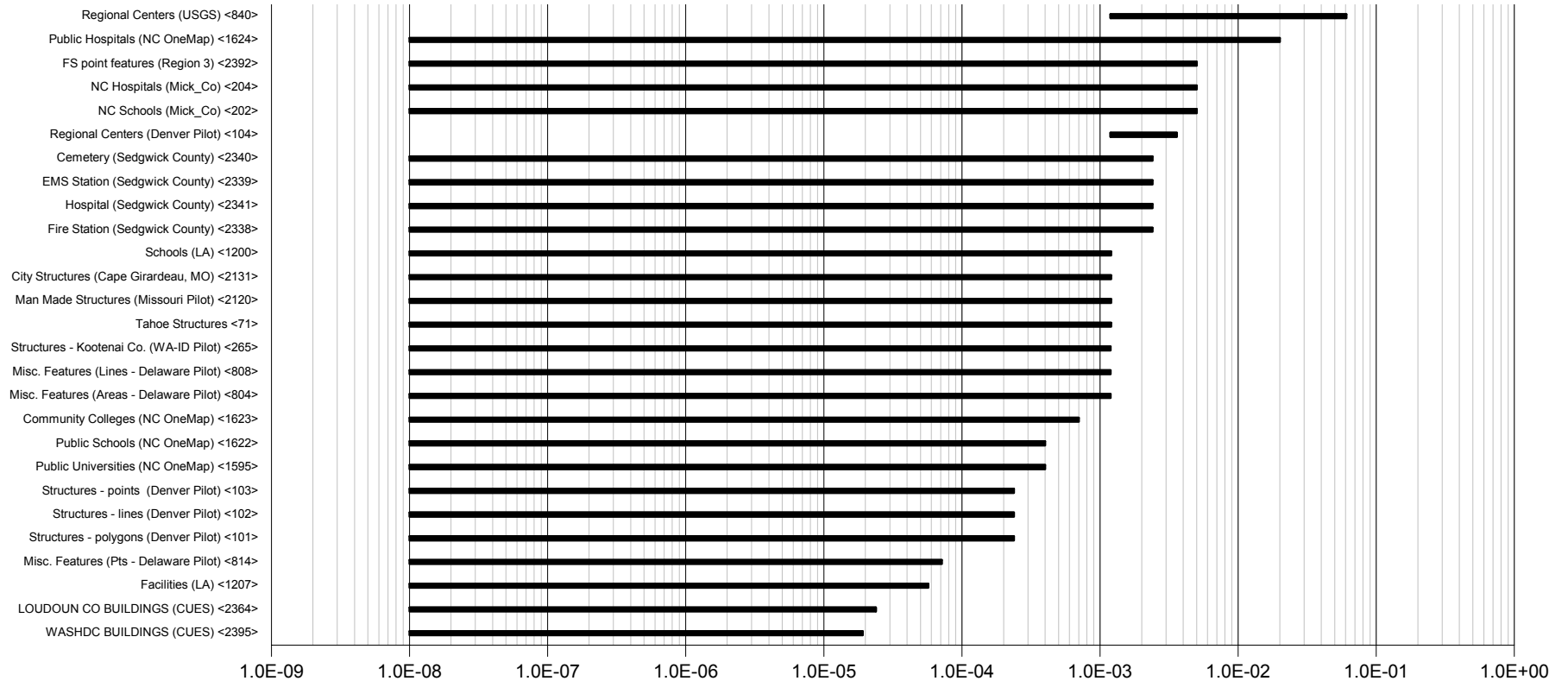
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Geographic Names Data Theme



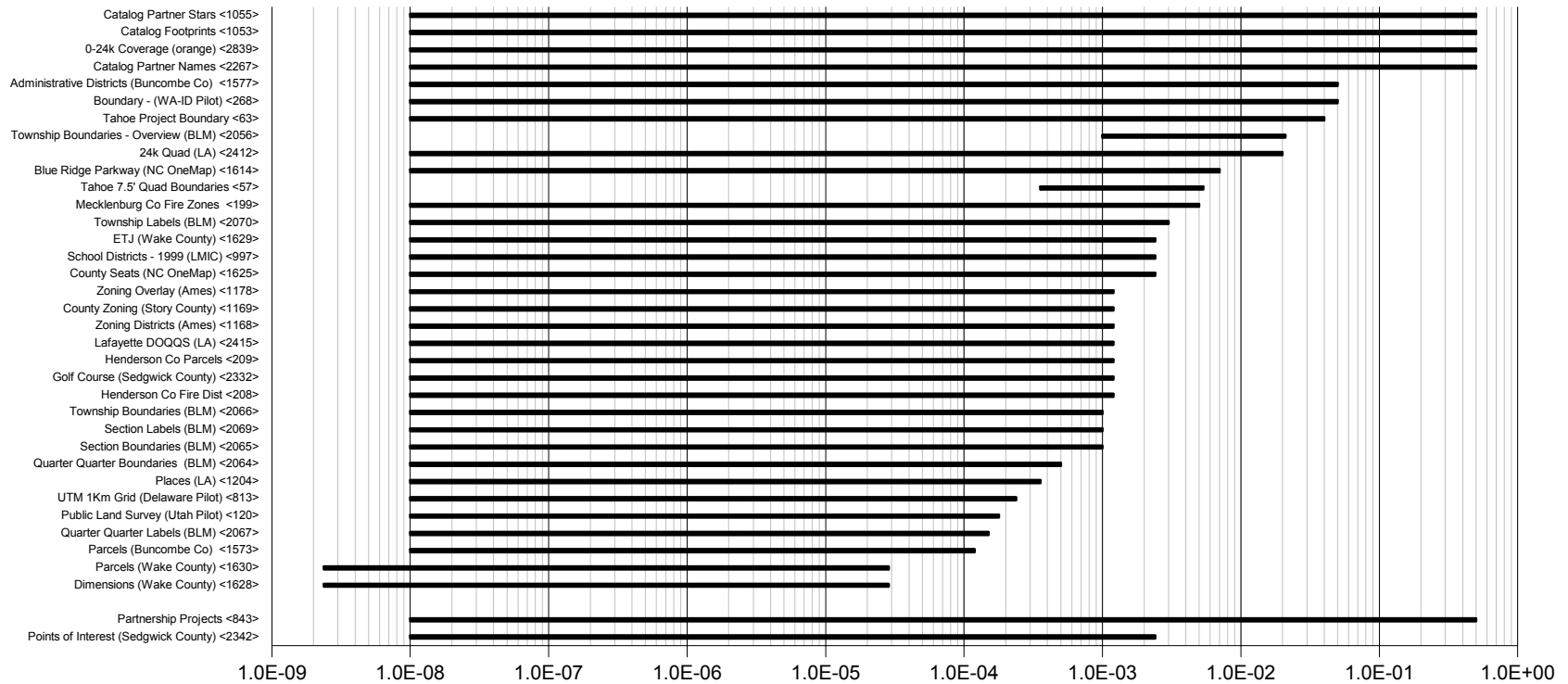
Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Structures Data Theme



Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.

Viewscales for Other and Administrative Data Themes



Data are from The National Map Catalog, November 25, 2003. Refer to Fig 1 and associated narrative in the body of this report for explanation of the graphs.